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Energy Systems Group Annual Progress Report 1 January - 31 December 1980

Edited by
Gordon A. Mackenzie and Hans Larsen

Risø National Laboratory, DK-4000 Roskilde, Denmark
February 1981

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ENERGY SYSTEMS GROUP

Annual Progress Report 1 January - 31 December 1980

Edited by Gordon A. Mackenzie and Hans Larsen

Abstract. The activities of the Energy Systems Group at Risø during 1980 are described. The work is presented in chapter 2, the work can be divided into two main areas: computer modelling using energy-economy models, and analysis of technical and economic aspects of specific parts of the Danish energy system. Furthermore a survey is given of the group's educational activities and publications. A list of staff is included.

EDB descriptors: DENMARK, ENERGY ANALYSIS, ENERGY DEMAND, ENERGY MODELS, HEATING, PLANNING.

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CONTENTS

1. INTRODUCTION

The Energy Systems Group (ESG) at Risø was first established in the summer of 1977 as a temporary interdepartmental group. The Group became an independent section directly responsible to the Risø board of managers in February 1980. ESG is multi-disciplinary, at present consisting of a permanent staff of 3 economists and 7 scientists together with 2 research students, 2 part-time consultants, 1 part-time undergraduate assistant, and 2 secretaries.

The Group is involved in a wide range of tasks within the field of energy systems analysis, which must be seen in the general sense of technical and economical assessment of the Danish energy system as well as its interrelationship to the international energy system. Such tasks involve detailed analyses of selected parts of the energy system as well as technical and economic investigations of specific energy technologies. The aim of the Group is to undertake a mix of tasks reasonably balanced between fundamental work, partly carried out by postgraduate students, and tasks related to actual energy planning. As the work of the Group is rather outward-looking it very often involves collaboration with other organisations both in Denmark and internationally.

The activities of the Group can be roughly divided into two main areas: computer modelling using energy-economy models developed both locally and elsewhere, and analysis of technical and economic aspects of specific parts of the Danish energy system. Most of the staff members are involved to a greater or lesser extent in both types of activity.

The computer modelling activities in 1980 have been predominantly concerned with work on the European Commission's energy modelling programme which involves medium- and long-term models for energy supply and demand. Other model activities are work on the Danish Energy System (DES) Model, which calculates the total Danish energy demand as well as the associated cost of investment, and development of a model for the simulation of combined heat and power production. In addition to the energy model work an important activity is the establishment and maintenance of databases containing statistical data on energy consumption, economic activities, etc.

Of the specific energy systems studies undertaken by the Group in 1980 the following can be mentioned:

- Participation in the development of The Danish Heat Plan. This work was completed in the beginning of 1980.
- Participation in the work concerning a new Danish Energy Plan (EP-81), initiated by the Danish Energy Ministry medio 1980, and to be completed in 1981. This work has been one of the major tasks undertaken by the Group in 1980.
- Contribution to a study of the comparison of the economy of coal-fired and nuclear power stations undertaken by the Danish Economic Council.
- The initiation of a postgraduate project on pricing policies.

As mentioned above, many of the tasks performed involve collaboration with other organisations such as the Energy Ministry, the Danish Energy Agency, and the electrical utilities. In addition, members of the group take part in various national and international committees such as the Energy Committee of the Danish National Science Foundation, a joint Nordic group for non-nuclear energy research, and the European Commission ACPM on Energy Modelling.

2. THE WORK OF THE ENERGY SYSTEMS GROUP IN 1980

2.1. Energy Models

One of ESG's main activities is the development, implementation, and use of computer models for the investigation of various aspects of energy systems. This involves both locally developed models, such as one for the simulation of combined heat and power (CHP) production, the Danish Energy System (DES) model, and models which have been developed abroad such as the EC medium- and long-term models. A closely related activity is the collection and maintenance of databases pertaining to energy and economics in the country and the development of software for processing this data.

2.1.1. The Danish Energy System (DES) Model

The expenses involved in the importation, conversion, and distribution of energy make up a not insignificant fraction of a country's budget. In evaluating plans for the development of the national energy system it is therefore important to be able to calculate the economic consequences of the possible choices which are available.

A model, DES, has been developed to calculate the total Danish energy demand and the associated cost of investment, fuel, operation, and maintenance. The model was derived from the program LPS (Long-term Planning System) developed by the electrical utility ELKRAFT. LPS contained a model for the simulation of power station operation, including CHP, together with calculations for the investment and running costs required for such operation. The program was extended by ESG for use in a study of electrical heating by adding a section which calculates the economic consequences of the total energy demand, with CHP, natural gas and electrical heating as alternative modes of space heating, and includes the energy demand for transport and industrial production. The model was thereafter named DES.

The calculations are based on a projection of the demand for useful energy (heat, electricity, etc.) and a set of values for economical quantities such as fuel prices, labour costs, interest rates, etc. The demand for primary energy is then calculated, taking into account conversion and transmission efficiencies. The way in which the demand for useful energy is satisfied obviously depends on national energy policy. This policy is reflected in the model by specifying values for the projected capacity for wind power, the extent of solar heating, the maximum amount of electrical space heating, etc. The model then attempts to satisfy the energy demand following a series of assumptions of diminishing priority which also take into account national energy policy:

(a) Production of electricity by wind power using the projected installed capacity is given first priority. The rest of the demand for electricity is met by thermal stations with an appropriate optimisation of the distribution of production.

(b) The part of the district heating net that is coupled to CHP stations is supplied first. If the heat produced as a byproduct of electricity generation is insufficient then the extra heat required is supplied by peak-load stations.

(c) The part of the district heating net not connected to CHP stations is supplied, as far as possible, by heat from refuse incinerators because of the low price of this fuel. Thereafter natural gas is used to the extent specified in the energy plan. Any residual demand is met by oil-fired district heating stations.

(d) The demand for domestic heating in buildings not connected to a district heating grid is met first by solar heating, heat pumps, straw burning, and natural gas. Next, a specified amount of electrical heating is introduced and finally the residual demand is satisfied by domestic fuel oil.

Once the assignment of the various energy sources has been made the program calculates the actual demand for primary energy, i.e. coal, oil, nuclear fuel, etc. using the appropriate factors for conversion and transmission efficiencies. Most of the operations involved in the program are of a simple bookkeeping character. One exception to this is the section in which the operation of the electricity and CHP system is simulated in order to obtain an economically optimal distribution of production over the different generation units, i.e. load dispatching. The simulation is based on given load duration curves which are assumed to remain unchanged throughout the period under study. (A more sophisticated simulation model for the operation of the power generation system is described in Section 2.1.2). On the basis of the optimal distribution of production the model then calculates the amount of fuel required for each generating unit and the associated costs for fuel, operation, and maintenance.

Also included in the DES model is an economic submodel which calculates the annual flow of money necessary for investment, fuel, operation, and maintenance. Thus, the total annual expenses can be found, accumulated over the whole period and discounted to give the present value associated with a particular national energy plan. The influence on the balance of foreign payments can be calculated by specifying the import value of the various elements of expenditure.

Finally, if the economic effect of a particular measure is to be investigated, then the internal interest rate can be calculated. This requires that the calculation be run twice, with and without the particular measure, e.g., increased thermal insulation of buildings.

The DES model has been used by ESG in the Electrical Heating Study which was carried out in association with the electrical utilities (see Section 2.2.1.) and in the study of nuclear power undertaken by the Danish Economic Council in 1980 (see Section 2.2.3.). At the time of writing the DES model is being used to calculate the economic consequences of the various alternatives considered in the Danish Energy Plan EP-81, described in Section 2.2.2.

2.1.2. A Model for the Simulation of Combined Heat and Power Production

The expected increase in the use of combined heat and power generation in Denmark means that the demands for planning are different from those which have been made in the past. This applies both to the planning of future expansion and to the organisation of the day-to-day running of the power generation system. The latter involves the selection of units to be started and how the load should be distributed between these units. The present system includes one heat storage facility with a capacity so large that it has a significant effect on the organisation of the local system. It is expected that more units of this kind will be added in the future.

A research project aimed at developing a computer model to simulate the Danish electricity production system, taking into account the factors mentioned above, is being carried out by ESG in collaboration with the Electric Power Engineering Department of the Technical University of Denmark.

The model can be run for either of the two electricity supply areas corresponding to those served by the two companies, ELSAM (Jylland-Fyn) and ELKRAFT (Sjælland, Lolland, Falster, Møn). There will also be facilities in the model for taking into account those power transmission connections already existing to Norway, Sweden, and West Germany and an expected future connection between the two Danish regions. It will be possible to use the model to simulate the operation of the system over a short period of time, taking into account the coupling between heat and electricity production, in order to find an optimal strategy for unit commitment and load dispatching. In addition, it will be possible to run more simplified simulations for a period of years in order to obtain an economic evaluation of different development plans and to ensure that these plans are sensible as far as the operation of the system is concerned.

The value of different components of the system, such as windmills and heat storage facilities, could be investigated by running simulations with and without these components.

The development of the model will be completed during 1981 and it is expected that the project as a whole will be completed by the summer of 1982.

2.1.3. The European Commission's Energy Models

The philosophy behind the European Commission's programme on energy systems and modelling, and details of the individual models are fully described in the publication "Energy Models for the European Community" (1): consequently, only a brief description of the models is given here.

2.1.3.1. The Medium-term Demand Model The medium-term demand model consists of 3 independent models: a macroeconomic model EURECA, an input-output model EXPLOR, and an energy demand model EDM. The macroeconomic model is centred around a production function of the Cobb-Douglas type, which takes into account three factors of production: capital, labour, and energy. The model calculates gross national product, private and public consumption, investments, etc. The input-output model EXPLOR describes the intersectoral dependencies within industry. Its main task is to divide the total private consumption (given from EURECA) into 64 consumption groups with the aid of a linear expenditure system and to compute the activity in each of the 35 production sectors and the corresponding cost-determined sector prices. The calculated prices then become input to EURECA, which recomputes the macroeconomic quantities. The procedure is repeated until convergence is attained and the final production values and prices are calculated by EXPLOR. In the energy demand model EDM

(1) Energy Models for the European Community. ed.A.Strub. Energy Policy, IPC Science and Technology Press Ltd. 1979.

an aggregation of the 35 production sectors is undertaken to give 13 energy-consuming sectors. The energy consumption in these sectors is subdivided into 9 energy products.

The models for the 9 EEC countries are coupled by means of a specially developed multinational version of EURECA which is run centrally in Brussels.

As its name implies, the model complex is concerned with estimating energy demand in the medium-term, which means a time horizon of 5-10 years. The estimate is made primarily on the basis of data obtained from the input-output tables and energy balances of the Danish Statistical Office.

During the past year the work with the medium-term model complex has been primarily concerned with the running of 2 case studies which consist of

1) constant energy prices (base case)
2) 5% p.a. increase in energy prices in real terms (high case)

In addition to these applications of the model, work has been carried out on improving the software and updating the database.

<u>2.1.3.2. The Long-term Demand Model</u> Early in 1980 ESG began working on the European long-term demand model. The model is entitled MEDEE 3 and was developed by the Institut Economique et Juridique de l'Energie (IEJE), Grenoble, France. The details of the model are described by Chateau and Lapillonne (1). MEDEE 3 simulates the evolution of energy demand over a period of 20 to 30 years. Energy demand is calculated for a set of consumption sectors which are, as far as possible, homogeneous with respect to social need or economic activity, consumer behaviour, and technological context. The model is therefore highly disaggregated and requires a very large amount of social, economic, and technical data. The socioeconomic system

is divided into 3 subsystems:

Urban system:	dwellings, education, commerce, offices etc., urban passenger transport.	
Production system:	energy-intensive industries	(8 sectors)
	other industries	(4 sectors)
	agriculture	
	construction	
Transport system:	interurban passenger transport, goods transport.	

The model allows the comparison of energy demand corresponding to alternative development scenarios for the socio-economic system. These scenarios are specified by a relatively small number of so-called "scenario indicators" which select different evolutionary paths for the technical, political, social, and economic features of the system under consideration. A procedure exists whereby the consistency and plausibility of the scenarios can be checked.

The first stage of our involvement with MEDEE 3 consisted of familiarisation with the approach and the way in which the model itself is constructed. Thereafter, the tasks of implementing the model on the Risø computer and the collection of data for Denmark were begun.

Implementation of the MEDEE 3 software on the Risø computer (Burroughs 6700) has proved to be problematic. It has been necessary to translate the program from its original language, an adaptation of PASCAL, into ALGOL which is implemented on the Risø computer. It is expected that the program will be ready for running early in 1981.

The major part of ESG's effort with MEDEE 3 in the latter half of 1980 involved the collection of the data for Denmark to be used in the first runs of the model. A preliminary database assembled by IEJE was checked and revised where necessary. Particular attention was paid to the sections related to space heating and transport which comprised about 33% and 17% of

Danish energy demand in 1980, respectively. The task of obtaining suitable data for these sectors was greatly eased by the existence of very detailed statistical registers of population and buildings and several recent studies (2), (3), (4), (5), and (6).

The production system in Denmark, in contrast to those of most of the other EEC countries, consists mainly of light energy-consuming industries, the only energy-intensive industries of any appreciable size being steel and cement. The data for the production system could therefore be treated in a more aggregated way than was the case with the urban and transport systems.

2.1.3.3. The Energy Flow Optimisation Model The supply part of the European Commission's energy model complex consists of the energy flow optimisation model EFOM. This model uses the technique of linear programming to find the optimal energy supply structure which satisfies the demand computed by either the medium- or long-term energy demand models. The energy system is subdivided into 17 subsystems which describe the main processes for energy extraction, production, conversion, storage, and transport together with the main energy-consumption processes. The latter include the 6 main energy-intensive industries, miscellaneous industries, transport, and the domestic

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(2) Varmeplanudvalgets 3. delbetænkning (The 3rd report of the Danish Heat Plan committee) Energiministeriet 1980.

(3) Elvarme i den fremtidige energiforsyning (Electrical Heating Report) Danske Elværkers Forening, 1979.

(4) Bolig og Varme, Jørgen Nørgård, Demo Projektet (Dwellings and Heating, Dynamic Energy Model Project) Fysisk Lab.III DtH (Technical University of Denmark, 1977.

(5) Trafikundersøgelse - 1975 (TU-75) ("Trafic Study 1975) Trafikforskningsgruppen - ATV, DSB, Vejdirektoratet, 1976.

(6) Trafik-2000, Trafikforskningsgruppen - ATV, Akademisk forlag, 1977.

sectors. Given a series of projections for energy comsumption from the appropriate demand model, EFOM finds the optimal system for the satisfaction of this demand. Normally this means minimising the total cost of energy supply. As the long-term demand model MEDEE is not yet operational for Denmark, the use of EFOM has been confined to the medium-term case until now.

The work with EFOM in 1980 was primarily concerned with preparations for the running of the model at an international level for all 9 EEC countries, which meant that a great deal of attention had to be paid to harmonising data collected in the individual members states. The first case study entitled "Escalating supply rationing" was initiated during this period. The purpose of this study is to investigate the effect of reducing the total amount of imported energy. The energy demand to be satisfied is taken from the projections of the medium-term model complex, EURECA - EXPLOR - EDM. The total energy import is assumed to have the value I for the initial year. The energy import is then constrained to be less than x.I, where x is a parameter which can be progressively reduced from 1 to 0 in successive runs of the model. It is then possible to calculate the substitution costs from the value of the object function which gives the present value of the total expenditure on energy. It is expected that work on this case-study will be completed in the first few months of 1981.

2.1.4. Databases

A great deal of the work which is performed by ESG involves the processing of large amounts of statistical data of the various sectors of society pertaining to energy consumption, economic activity, etc. It is important for such work to have easy access to a detailed and well-documented set of data and to have the necessary computer software for data retrieval and processing. The establishment and maintenance of such databases together with the development of software can be regarded as a support activity to the other tasks that are performed by the Group.

During the past year ESG has obtained access to databases which contain:

(1) The Danish Statistical Office (DS) National Accounts Department's, Input-Output Tables for 1966-75 classified into 130 sectors and 79 final demand categories.

(2) DS's Energy Balances classified according to 130 sectors and 21 energy types for 1966-76.

The latter is complemented by the addition of statistics from the Danish Energy Agency (ENS) and the Danish Association of Electricity Supply Undertakings (DEFU) for energy and electricity, respectively, for the period 1975-79.

There are, however, inconsistencies between the energy statistics of DS and ENS/DEFU because the former set is consumer oriented while the latter is supplier oriented. A considerable amount of work has already been devoted to accounting for these inconsistencies and it is hoped that a consistent database which includes data from all three sources will be completed in the near future.

Software has been developed to access the above-mentioned databases and perform aggregations over specified sectors and/or energy types.

2.2. Energy Systems Analysis

Although most of the work performed by ESG could be described as energy systems analysis, in this section we take this term to mean the study of specific parts of the Danish energy system, or indeed the study of the system as a whole. In many cases such work involves the use of the computer models described in the foregoing sections. The main studies undertaken during the past year, the Danish Heat Plan and the Danish Energy Plan EP-81, are described below. Examples of studies performed in 1979 are the appendix to the Energy Report 1979 (7) on security of supply (8) and the report on electrical heating (3). The latter is described briefly in Section 2.2.1.

2.2.1. The Danish Heat Plan

In June 1980 more than three year's work on a national plan for space heating was completed. A broadly based committee, set up by the Danish Energy Agency and representing all interested parties in the Danish public administration, presented its conclusions in a three-volume report together with several appendices to parliamentary documents on energy policy. The three volumes of the report were entitled:

1) Planning of space heating (October 1977).
2) Organisation and operation of a national plan for space heating (April 1978)
3) Renewable energy, alternative energy, and electricity for space heating (April 1980).

The objectives of the plan can be briefly stated as follows:

- introduction of natural gas for up to one-third of consumers,
- further development of district heating based on CHP for over one-third of consumers, and
- concentration on renewable energy for the supply of space heating to the remaining one-third of consumers.

The target year set for the realisation of the above objectives is 1995. ESG has been involved in tasks directly and indirectly related to the Heat Plan since its initiation. The first two reports utilised a "heat map" which was prepared and maintained by ESG. This took the form of a computerised database containing information on the space heating requirement in Denmark with the country subdivided into about 800 geographical

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(7) Energy Report (ER79), Ministry of Commerce, Copenhagen, 1979.

(8) Vurdering af forsyningssikkerheden for det danske energisystem frem til 1995 (Evaluation of security of supply in the Danish energy system until 1995), appendix to ER79, Risø 1979.

areas. The heat map was used by the Heat Plan Committee to delimit the areas of the country which could best be served by natural gas and by CHP-based district heating.

During 1979 ESG was involved in a independent study of the possibilities for electrical heating in the areas of the country served by neither natural gas nor CHP. This study, carried out for the Danish Association of Electricity Supply Undertakings (DEF) by ESG and the research department of DEF (DEFU), resulted in renewed interest in the use of electrical storage heating, a hitherto rare form of heating in Denmark. The report from this project was published in November 1979 (3).

The third volume of the Heat Plan was carried out between autumn 1979 and spring 1980 and involved a working group of 5 persons of whom 3 were members of ESG. Other members of ESG worked for shorter periods on the appendices to the report. The sections for which ESG members were responsible were Chapters III and IV together with the appendices on geothermal energy, electrical heating, and heat pumps. In addition, the economic calculations for the appendices on biogas and windmills were carried out by ESG.

2.2.2. Energy Plan EP-81

In the spring of 1980 the Danish Energy Ministry initiated work on a national energy plan to be presented before the Folketing, The Danish Parliament, during 1981. The aim of this plan is to give a detailed description of the possible development in energy demand between now and the year 2000 and to describe the form and the economic consequences of the alternative possibilities for supplying this demand. It is also planned to examine the longer term situation, from 2000 to 2030, though in somewhat less detail because of the greater uncertainties involved. A number of working parties were set up to study the demand, supply, and administrative aspects of the Danish energy system. The topics studied by these groups were as follows:

1. Process energy	Demand
2. Space heating	
3. Transport energy	
4. Electricity demand	
5. Imported energy	Supply
6. Domestic energy production (Hydrocarbons)	
7. Technical aspects of the supply system	
8. Means of regulating demand	Administration

On top of these eight groups a coordination committee was set up to monitor the work on the various topics. The working groups were made up of representatives from various ministries and other public authorities with interests in the specific sectors or in energy in general. The Energy Systems Group was represented in groups 1 to 7.

The tasks delegated to the demand groups consist of the collection of historical data relating to the respective sectors and the formulation of energy demand forecasts based, in the first instance, on two alternative scenarios: a neutral scenario in which no additional energy-saving measures over and above those already existing or planned are introduced, and a scenario on which energy demand is controlled by measures which are technically, economically, and politically realistic. The main contributions from ESG have been the collection of statistical data and participation in the formulation of the forecasts for process energy, space heating, and electricity demand.

On the energy supply side the contributions from ESG have included the estimate of future energy price development, the compilation of a comprehensive list of technical and economic parameters for energy conversion equipment, a detailed study of the technical and economic aspects of CHP production and the calculation of the technical and economic consequences of supplying the forecasted energy demand. The latter task which involves the use of the DES model, described in Section 2.1.1., takes the results of the work of all the demand groups together with the technical and economic data compiled by the supply groups and simulates the whole national energy system for the period under consideration. The calculation will be run for a number of alternative development plans with and without nuclear power and with more or less use of natural gas, renewable energy sources, and decentralised CHP stations. As this work depends to a great extent on the results of the other groups the calculations are expected to be completed during the later stages of the Energy Plan.

A status report describing the assumptions, aims, and preliminary results of the work was issued in January 1981. At present the work on EP-81 is continuing, and a final report is expected to be issued later in 1981.

2.2.3.The Economic Council's Study of Nuclear Power

In June 1980 the Danish Economic Council issued a report in which the introduction of nuclear power in Denmark was discussed (9). The contribution of ESG to this study consisted of a detailed examination of two alternative plans for the future development of the electricity generation system, with and without nuclear power. In the latter alternative all new power stations were assumed to be coal fired. As the parameters involved in a comparison of this kind are subject to great uncertainty a series of calculations was made in which quantities such as electricity demand, the real rate of interest, and fuel prices were given different development profiles, both increasing and decreasing. It turned out that in all cases studied there is an economic advantage in introducing nuclear power, although this cost advantage may in some cases be small in comparison to the total cost of generating electricity. The calculations done by ESG made use of the DES model described in Section 2.1.1.

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(9) Dansk Økonomi og Energiproblemerne, Det Økonomiske Råd, (Danish Economic Council), Direktoratet for Statens indkøb, Copenhagen 1980.

2.2.4. Pricing Policies and Tariff Structures in Space Heating

In October 1979 work was begun on a Ph.D. project aimed at studying the technical, economic, and political factors involved in the transition to North Sea gas for space heating in Denmark. The work concentrates primarily on the pricing and investment decisions of the public utilities that supply space heating. It is intended to develop models to investigate the influence of technical, economic, energy-economic, and organisational interactions in the energy system for space heating on such pricing and investment decisions.

The work on the project during the past year has consisted mainly of a study of the existing literature on the subject and the formulation of a technical/economic description of the energy systems which make up the Danish space heating system.

Although the work is of particular relevance to the Danish Heating Plan it can also be seen in connection with the work on socioeconomic forecasting models such as MEDEE in which there is a very general description of the choice of technology which depends on present value and other economic and non-economic parameters. Such a model can be expected to give reasonable results for long-term energy demand forecasting only if the functions describing the switch-over between technologies give a reasonable description of consumer behaviour. It is hoped that this study will provide useful background information which can be applied to energy-demand forecasting models.

3. EDUCATIONAL ACTIVITIES AND PUBLICATIONS

3.1. Public Relations Activities

Since its formation the Energy System Group has been involved in the communication of information concerning all aspects of energy to the public. Several ESG staff members regularly give public lectures, and a number of articles have been published in the popular as well as technical press.

One of the major items in this field during the past year has been the planning and construction of an energy exhibition which was presented at Legoland in Jutland from May to September 1978 and at the Danish Technical Museum, Helsingør, from October 1980 to March 1981. The exhibition was aimed at people of all ages but with a particular concentration on school pupils. To this end a teacher's booklet and pupil's leaflet were prepared containing a series of questions on energy and a set of proposals for projects. The material has been used by more than 25,000 Danish school children in the past year.

The Energy Systems Group considers public relations to be an important and integral part of its work, both when this involves communication on a large scale, such as described above, and on the individual level when members of the Group offer advice to the public on energy matters.

3.2. Lectures

CHRISTENSEN, P.S., Forsyningssikkerhed (Security of Supply), The Institute of Economics, University of Copenhagen (May 1980).

HOUMANN, J., The Danish Heat Plan, Risø (November 1980).

MORTHORST, P.E., And FENHANN, J. EF energi-økonomimodeller (The EC energy-economy models), The Institute og Economics, University of Copenhagen (March 1980).

MØLLENBACH, K., Elvarme (Electrical heating), The Institute of Economics, University of Copenhagen (May 1980).

3.3. Conference Contributions

CHRISTENSEN, P.S., Vurdering af forsyningssikkerheden for det danske energisystem frem til år 1995 (An evaluation of security of supply in the Danish energy system until the year 1995), Nordisk Energisymposium, Stockholm, 10-12 March 1980.

HOUMANN, J., Elvarme i den fremtidige danske energiforsyning (Electrical heating in the future Danish energy supply) Nordisk Energisymposium, Stockholm 10-12 March 1980.

MORTHORST, P.E. and FENHANN, J., EF energi-økonomi modeller (The EC energy-economy models), Nordisk Energisymposium, Stockholm 10-12 March 1980.

3.4. Publications

CHRISTENSEN, P.S., Energi og forsyningssikkerhed (Security of Supply),Reports from Risø No.3, Dansk Tek. Tidsskr. 104:2,10-15.

HOUMANN, J., Energisystemanalyse - en ny aktivitet på Risø (Energy systems analysis - a new activity at Risø), Reports from Risø No. 1, Dansk Tek. Tidsskr.103:11/12, 14-19.

HOUMANN, J., Kraftvarmeproduktion, fjernvarme og varmepumper (CHP, district heat and heat pumps - a report from the World Energy conference, Munich, 1980), Elektroteknikkeren 76, 606-607.

LARSEN, H., Sammenhængen mellem det fremtidige energibehov og produktionen (Interdependence between future energy demand and production - a report from the World Energy Conference, Munich, 1980), Elektroteknikkeren, 76, 603-604.

LARSEN, H.V., Energi-importen vejer stadig mere tungt i vores handelsbalance (Energy imports place an increasingly large burden on our balance of foreign trade - a discussion of computer analysis of the electricity and space-heating supply systems) Reports from Risø No. 5, Dansk Tek.Tidsskr. 104:4, 10-15.

and energy savings). Varmeplanudvalgets 3. delbetænkning, bilagsrapport 10, Energiministeriet 1980, 48 pp.

LAUT, P., Udviklingslandenes energiproblemer (The energy problems of the developing countries - a report from the World Energy Conference, Munich, 1980), Elektroteknikkeren, 76, 598-599.

MORTHORST, P.E., Energi-økonomi modeller (Energy-economy models - a discussion of the EC energy modelling project), Reports from Risø, No. 4, Dansk Tek. Tidsskr. 104:3, 10-14.

MØLLENBACH, K., Den store opgave i energiplanlægningen er opvarmning af bolig og arbejdsplads (The most important subject for energy planning is that of space heating - a discussion of Danish energy policy with reference to the Heat Plan and the Electrical Heating Report), Reports from Risø, No. 2, Dansk Tek. Tidsskr. 104:1, 12-19.

MØLLENBACH, K., El-energi - fortid og fremtid (Electrical energy - past and future) Populær Radio 53:12+13, 6+6.

MØLLENBACH, K., and HOUMANN, J.,Elvarme. En samfundsøkonomisk vurdering af forskellige typer elvarmeanlæg (an economic evaluation of different types of electrical heating) Varmeplanudvalgets 3. delbetænkning, bilagsrapport 9, Energiministeriet 1980, 44 pp.

4. STAFF

Leader:

Hans Larsen M.Sc. (DtH*), Ph.D. (DtH).

Physicist with postgraduate research in reactor technology, with the Reactor Technology Department at Risø from 1970 until 1980.
Visiting scientist at UKAEE Winfrith 1973-76 working on the OECD Dragon project. Joined ESG as leader in July 1980. Member of a joint Nordic group for non-nuclear energy research.
* Technical University of Denmark.

Deputy Leader:

Jens Houmann M.Sc. (DtH), Ph.D. (DtH).

Physicist with postgraduate research in solid state physics, with the Physics Department, Risø from 1968 until 1977. Visiting scientist at Oak Ridge National Laboratory, USA, 1968-69. Founding member of ESG and acting leader 1979-80. Vice-chairman of local district heating company, Svogerslev. Member of European Commission ACPM on energy modelling since 1979. Member of the Energy Committee of the Danish National Science Foundation, Advisory Committee on Energy Education of the Southern Jutland University Centre and the Risø Computer Committee. Main interest within ESG is the study of energy supply systems especially combined heat and power production.

Permanent staff:

Frits Møller Andersen M.Econ. (Århus).

Economist specialised in computer modelling and econometrics. Worked as teaching assistant in the Institute of Statistics, Århus University and as economic planner in local government before joining ESG in May 1980. Main activities within ESG consist of the development, implementation, and use of econometric models for energy demand forecasting.

Peter Skjerk Christensen M.Sc. (DtH).

Physicist with previous experience in reactor physics in the Reactor Technology Department, Risø before joining ESG as a founding member. Activities within ESG include modelling of electricity and heat production and transmission systems, modelling of total energy systems and maintaining an up-to-date knowledge of the construction and operation of power reactors and of the nuclear fuel cycle.

Jørgen Fenhann M.Sc. (Copenhagen).

Physicist with mathematics and chemistry as subsidiary subjects. After 1 year of teacher training taught at high school and DtH. Since July 1977 worked on the EC energy model programme, first with the Niels Bohr Institute, University of Copenhagen and since November 1978 with ESG. Interests within ESG include development of software for the long-term model, databases, and running of the energy-flow optimisation model.

Poul Erik Grohnheit M.Econ. (Copenhagen).

Economist, before joining ESG worked with The Danish Buildings Research Institute (1969-71), as a town planning consultant (1971-72 and 1979-80) and on economic planning in local government (1973-79). Joined ESG in May 1980. Main interest within ESG include energy economics, town planning, and local government.

Gordon A. Mackenzie B.Sc. (Edinburgh), Ph.D. (Edinburgh).

Physicist with postgraduate work in solid state physics. First came to Denmark in 1974 to participate in physics experiments at Risø. Postdoctoral work in Physics Department, Risø 1976-78. Lecturer in physics at Edinburgh University 1978-79. After a further period at Physics Department, Risø, joined ESG in February 1980. Main interests within ESG are the long-term model MEDEE and transport energy.

Jørgen Marstrand M.Sc. (DtH), D.Techn. (DtH).

Mechanical engineer with experience in the shipbuilding industry and the Danish Factory Inspectorate before joining Risø in 1957. Doctoral thesis "Methods of Hydrodynamic Computation of Ship Propellers" published 1952. Former head of Engineering Department at Risø and chairman of the Safety Committee for the reactor DR 2.

Played a leading role in the design and construction of various installations at Risø, including the Hot Cell. Contributions within the field of reactor technology include the invention of a new type of fuel assembly for boiling-water reactors employing a hexagonal arrangement of fuel rods and twisted deflectors. Active participant in the public debate on future energy sources and the role of nuclear power. Worked with the Reactor Technology Department, Risø before being attached to ESG in 1980. Present activities include the collection and examination of technical and economic data for energy conversion systems.

Poul Erik Morthorst M.Econ, (Århus).

Economist specialised in econometric forecasting. Research assistant at Institute of Economics, Århus University from 1976 to 1977. Joined ESG in June 1978. Main activities within ESG include the implementation of the EC medium-term demand model and forecasting of electricity demand.

Knud Møllenbach M.Sc. (DtH), Ph.D. (DtH).

Physicist with postgraduate experience in spectroscopic methods at the Physics Department, Risø from 1975. Joined ESG in January 1979. Activities within ESG have included work on the Electrical Heating Study, The Danish Heat Plan, strategic planning for the Risø Board of managers with particular reference to coal, planning of exhibitions, and preparation of educational material.

Postgraduate Students:

Henrik Andersen M.Sc. (DtH), B.Com. (HHK*).

Mechanical engineer with postgraduate qualification in economics. From February 1978 until September 1979 worked at DtH on estimate of design parameters for cooling towers at the Mechanical Engineering Department and on the Danish Solar Heating

Programme at the Thermal Insulation Department. Awarded a scholarship by Danish Council for Scientific and Industrial Research to work on the study programme on energy and economics, project on pricing policies and tariff structures in space heating begun October 1979.

* Copenhagen School of Economics and Business Administration.

Helge V. Larsen M.Sc. (DtH).

Graduated in electronic engineering in 1974 and subsequently worked as a university demonstrator at DtH and as an electronic engineer in industry. Joined Risø National Laboratory in 1976, engaged in computer modelling of radiation heat transfer in BWR fuel elements with the Reactor Technology Department. Later worked on Nordic project on modelling of district heating systems, based at Studsvik Energiteknik, Sweden. Currently developing a model for the simulation of power station operation.

Consultants:

Peter Laut, Lecturer, Engineering Academy of Denmark.

Svend Vørts, Professor (retired) Electrical Power Engineering, Technical University of Denmark.

Undergraduate assistant:

Jesper Schmaltz-Jørgensen.

Secretaries:

Jette Larsen
Susanne Valentin Nielsen